European Journal of Food Science and Technology

Vol.3, No.4, pp.11-19, September 2015

Published by European Centre for Research Training and Development UK (www.eajournals.org)

PROXIMATE, MINERAL AND FUNCTIONAL PROPERTIES OF DEFATTED AND UNDEFATTED CASHEW (*ANACARDIUM OCCIDENTALE LINN.*) KERNEL FLOUR.

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ABSTRACT: *Defatted and undefatted cashew (Anacardium occidentale Linn.) kernel flours were produced and the effect of defatting on the proximate, mineral and functional properties was determined. It was ascertained that the proximate content of protein, crude fibre and carbohydrate (34.0, 6.2 and 32.2%, respectively) increased significantly in the defatted compared to undefatted cashew kernel flour. A decrease was observed in the moisture content, ether extract (crude fat) and total ash (4.4, 1.6 and 1.8%, respectively) of the defatted flour. There was significant difference ($p<0.05$) in all the analysed mineral elements between the defatted and the undefatted flours except manganese with significantly higher ($p<0.05$) value in the undefatted compared to the defatted sample (9.0 and 2.9mg/100g), respectively. There was no significant difference ($p>0.05$) in the bulk density, foam capacity/stability, emulsion capacity and nitrogen solubility at pH8.0 of the defatted and undefatted cashew kernel flours. A significant difference was observed between these two samples in the water/fat absorption capacity, emulsion stability and nitrogen solubility at pH8.0. The results obtained in this study indicate that defatted cashew kernel flour is a good source of protein and can be used to substitute wheat flour in snack production and formulation of children's meals to reduce the importation of wheat flour into Nigeria. It can also be a useful source of low-fat fabricated foods as well as animal feeds.*

Keywords: Defatted/undefatted cashew kernel flour, quality characteristics.

INTRODUCTION

Current trend in nutrition is the consumption of functional foods "foods that not only supply basic nutrients but also help to prevent certain diseases" due to different health related problems associated with wheat flour consumption. These problems include celiac disease, diabetes and coronary heart disease (WHO/FAO, 2003). This situation has created the need for the consumption of low-carbohydrate diets, slowly digested starchy foods as well as an increased intake of functional foods (Hurs and Martins, 2005). Many plants usually in the form of protein extracts, fibre extract or seed flours are being investigated and tested for new products such as low cost fabricated foods with high nutritional value, attractive and acceptable to consumers. Snack products such as biscuits and cookies have been formulated from blends of wheat/fluted pumpkin protein concentrate(Giami and Barber, 2004) wheat/cashew kernel meals (Aroyeun, 2009), cassava flour/cashew apple powder (Ogunjobi and Ogunwolu, 2010), whole wheat and full fat soya (Ndife et al., 2014),wheat flour/cashew-apple residue as a source of fibre (Ebere et al., 2015), composite flour of plantain/Bambara groundnut protein concentrate (Kiin-Kabari and Giami, 2015).

Cashew (*Anacardium occidentale Linn.*) belonging to family *Anacardiaceae* is an extremely hardy tree that grows on poor soil under various climatic conditions. It is a native to Brazil and is being extensively grown in India, East Africa and Vietnam (Muniz et al., 2006). These countries including Nigeria are the main producers of cashew (Honorato et al., 2007). Cashew is one of the most important plantation crops earning huge amount of foreign exchange through its kernel and Cashew Nut Shell Liquid (CNSL). India is the World's largest exporter of cashew nuts followed by Brazil. Africa is third in terms of global production of cashew, producing approximately 100,000 tonnes of cashew nut per year. Africa gains little from the production as most of the nuts produced are exported to the USA, Netherlands and other European countries unprocessed. Some estimates suggested that Nigeria and other African countries loose about one hundred million dollars per year by not processing their nuts (Ogunmoyela, 1983).

In 2007, Nigeria produced about 660,000 MT of raw cashew nuts and studies revealed that only about 10% is utilized locally (FAO, 2008; Oduwole et al., 2001). The practical implication of this is that 90% is either wasted or exported unprocessed which attracts very low prices in international trade. This has led to studies of the physicochemical characteristics of cashew nut flour (Aremu et al., 2006), cashew kernel meals enriched cookies (Aroyeun, 2009), roasted and defatted cashew nut flour (Omosuli et al., 2009), effect of packaging materials, storage time and temperature on the colour and sensory characteristics of cashew-apple juice (Emelike and Ebere, 2015) and composite flour of wheat and cashew-apple residue as a source of fibre in cookie preparation (Ebere et al., 2015). All these efforts were aimed at reducing the wastage of cashew in Nigeria and the use of its by-products (cashew-apple residue and cashew nut flour) as functional ingredients.

The functional properties of commonly used plant materials like soybean, cowpea and pigeon pea have been studied extensively by many scientists (Narayana and Rao 1982). This is to evaluate how their flour proteins can be used to supplement or replace more expensive protein sources which are used traditionally (Akobundu et al., 1982) and to upgrade carbohydrate rich foods such as snacks and pap. However, research on the functional potentials of the defatted and undefatted cashew kernel flour is few. Hence, the purpose of this research work is to evaluate the effect of defatting on the proximate, mineral and functional properties of cashew kernel flour.

MATERIALS AND METHODS

COLLECTION OF MATERIALS

Mature, ripe cashew (*Anacardium occidentale Linn.*) apples, red and yellow varieties were harvested in an orchard at Uturu, Abia State, Nigeria. A total of ten kilograms of cashew nuts were used. All chemicals used were of analytical grade.

PREPARATION OF CASHEW NUT FLOUR

The nuts were sun dried for three days to prevent deterioration during storage. They were conditioned (mild spraying with water in a sieve) to increase flexibility and prevent scorching. The conditioned cashew nuts were divided into portions of 500g each for easy processing, placed in a metal basket and immersed in a pot of hot vegetable oil (corn oil) for 1min to make the shell brittle for shelling. The nuts were stirred at intervals of 10sec to prevent burning while in the hot oil. The Cashew Nut Shell Liquid (CNSL) of the nut extracted into the pot thus increasing the volume of the oil in the pot. The cashew nuts were poured out after 1 min and allowed to cool for about 1h. The brittle shell was broken with wooden mallet and the kernel extracted. The kernels were polled together which yielded 6.57kg. The kernel was further roasted in hot sand for 30min to facilitate easy removal of testa, cooled slightly and the testa removed manually.

ISSN 2056-5798(Print), ISSN 2056-5801(online)

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The kernel was cleaned, sorted for insect damage and discoloured kernels and divided into two equal parts. One was used to process undefatted cashew kernel flour while the other, defatted cashew kernel flour. The kernels were milled separately using Kenwood blender (Model A907D U.K). One part of the obtained flour was sieved using 0.400mm sieve and left at that stage as the undefatted cashew kernel flour. The other was further processed for the defatted flour by oven drying it at 105^{o}C for 1h to reduce the moisture content and to condition the fat molecules of the flour. The oil was extracted by solvent extraction with petroleum ether (b.p 40 – 60^{o}C) in continuous soxhlet extraction apparatus for 3h.The flour produced was sieved to remove larger particles or grains, forming a fine powder. The defatted and undefatted samples were analysed for their proximate, mineral and functional properties.

DETERMINATION OF PROXIMATE COMPOSITIONS

The recommended methods of Association of Official Analytical Chemist (AOAC, 2012) were employed in determining the moisture, crude protein, ether extract, ash and crude fibre contents of defatted and undefatted cashew kernel flour. Carbohydrate was determined using the Clegg Anthrone reagent method as described by Osborne and Voogt (1978).

DETERMINATION OF MINERAL CONTENTS

Mineral elements of defatted and undefatted cashew kernel flour were analysed for; phosphorous, iron, calcium, sodium, potassium, magnesium and manganese using an Atomic Absorption Spectrophotometer, AAS (Model 372, Perkin – Elmer, Beaconsfield, U.K) by wet digestion according to the method described by AOAC (2012).

DETERMINATION OF FUNCTIONAL PROPERTIES

Water Absorption Capacity

Water absorption capacity of both samples was determined using Sosulski (1979) method. One gram of cashew kernel flour was stirred into 10ml of distilled water in a centrifuge tube, after which the suspension was allowed to stand for 10 min and then centrifuged for 25 min at 2,500 rpm. The clear supernatant was decanted into a measuring cylinder and the adhering drops of water were removed by inverting the tube and the tube was weighed. The weight of water absorbed by 1.0g of flour was calculated and expressed as water absorption capacity.

$$Water\ absorption\ capacity\ (\%) = \frac{final\ weight\ of\ Y - X}{X} = 100$$

Where Y = Final weight of sample and tube and X = Initial weight of sample and tube.

Fat Absorption Capacity

The method of Lin et al., (1974) was used in the determination of fat absorption capacity. One gram of cashew kernel flour was added to 10ml of groundnut oil in a centrifuged tube, stirred together and allowed to stand for 30 min at room temperature (30±2^{o}C). The sample was centrifuged at 3,000 rpm for 30 min. The clear supernatant was decanted into a measuring cylinder, the adhering oil was removed by inverting the tube and the tube was weighed. The weight of oil absorbed by 1.0g of flour was calculated and expressed as fat absorption capacity in percentage.

$$\%\ Fat\ absorption\ capacity = \frac{Y - X}{X} x \frac{100}{1}$$

ISSN 2056-5798(Print), ISSN 2056-5801(online)

Where Y = Final weight of sample and tube and X = Initial weight of sample and tube.

Bulk Density

Bulk density was determined on the defatted and undefatted cashew kernel flour using the method of Narayana and Rao (1984). A weighed centrifuge tube of 10ml was filled with 10g of cashew kernel flour and the weight was recorded. This was subjected to a constant tapping with subsequent addition of the flour until no further change in volume was observed and then final weight was taken. The difference in weight was used to calculate the bulk density of the samples.

$$Bulk\ density = \frac{weight\ difference}{Initial\ volume}$$

Foam Capacity and Stability

Foam capacity and stability of the samples were determined using Coffman and Garcia (1977) method with some modifications. Two grams of defatted and undefatted cashew kernel flour was whipped with 10ml distilled water for 5 min in a Kenwood blender (Model A907D U.K) at high speed and poured into 250ml graduated cylinder. The volume of foam at 30 sec after whipping was expressed as the foam capacity and the volume of the foam over 30 – 60 min as foam stability for the respective time periods. The volume increase (%) was calculated according to the following equation;

$$Volume\ increase\ (\%) = \frac{volume\ after\ whipping\ (ml) - volume\ before\ whipping\ (ml)}{Volume\ before\ whipping}\ x\ \frac{100}{1}$$

Emulsification Capacity and Stability

Emulsion capacity and stability was studied using the method described by Beuchat (1977). Two grams (2g) of samples were blended in a Kenwood blender (Model A907D, U.K) with 100ml of distilled water for 30 sec at high speed. After complete dispersion, vegetable oil (corn oil) was added continuously in 5ml portions from a burette. Blending continued until the emulsion breakpoint (separation into two layers) was reached. The emulsion capacity was determined at room temperature (30±2^{o}C) and the emulsion capacity was calculated using the formula;

$$Emulsion\ capacity\ (\%) = \frac{Height\ of\ emulsion}{Total\ height\ of\ liquid}\ x\ \frac{100}{1}$$

The stability of the emulsions were evaluated by keeping the emulsion at room temperature (30±2^{o}C) for 20h, noting the separation of water in the graduated cylinders, the emulsion stability was calculated using the equation;

$$Emulsion\ stability\ (\%) = \frac{Volume\ of\ water\ separated}{Total\ volume\ of\ liquid}\ x\ \frac{100}{1}$$

Nitrogen Solubility Index

Nitrogen solubility of the flour samples were determined using the method described by Narayana and Rao (1984). Quantity of 0.5g of the defatted and undefatted cashew kernel flours was mixed with 30ml phosphate buffer between pH ranges of 8.0 – 9.0. The mixture was allowed to stand for 2h at room temperature (30±2^{o}C). The suspension was then centrifuged for 40 min. At a speed of 2,000rpm, the supernatant was decanted and used to estimate the nitrogen content by Kjeldahl method. Nitrogen extracted was expressed as the percentage of the flour nitrogen.

$$Nitrogen\ solubility\ index\ (\%) = \frac{Soluble\ nitrogen}{Total\ nitrogen\ of\ sample}\ x\ \frac{100}{1}$$

Statistical Analysis
Results were expressed as mean values and standard deviation of five (5) determinations. The obtained data were analysed using a one-way analysis of variance (ANOVA) using Statistical Packaging for Social Science (SPSS) version 20.0 software 2011 to test the level of significance ($p<0.05$). Duncan New Multiple Range Test was used to separate the means where significant differences existed.

RESULTS AND DISCUSSIONS

Proximate composition
Moisture content of cashew kernel flour was 4.4% for defatted and 5.7 for undefatted as shown in Table 1. Hussain et al., (2008) reported a significant reduction in the moisture content of partially defatted flaxseed which agrees with the observation in this study. This indicates that defatting decreases the moisture content of raw materials and food materials with low moisture content have the benefit of been stored for a longer periods. Protein content of the defatted flour (34.0%) is significantly higher ($p<0.05$) compared to that of undefatted sample (19.8%).This is within the range of protein content of soybean (35.1%) and melon seed (33.3%)reported by Achinewhu (1983) and Hussain et al., (2008) for partially defatted flaxseed flour (34.6%). It was significantly higher than that reported by Omosuli et al., (2009) for roasted and defatted cashew nut flour (27.31%) and Aremu et al., (2006) for cashew nut flour (25.3%). The difference in these reports could be as a result of the processing methods applied which might have reduced the protein content of the raw material. The recommended daily allowance of protein for children ranges from 23.0 – 36.0g and adults 44 – 56g (NRC, 1989). However, it can be evaluated that defatted cashew kernel flour is a good source of protein substitute/enrichment since it can supply the recommended daily intake of protein for children. Defatting significantly decreased the ether extract (crude fat) of cashew kernel flour to 1.6% from 47.1% for undefatted sample. These values are in agreement with those reported by Fetuga et al., (1974) for undefatted cashew kernel, melon seed and groundnut (48.1, 53.3 and 55.2, respectively) and are regarded as oil seeds (Achinewhu, 1983). Crude fibre of defatted flour (6.2%) is significantly different ($p<0.05$) compared to undefatted sample (1.2%) and it compared very well with those of legumes with mean values ranging from 5 to 6% as reported by Anonymous (1972) and Aremu et al., (2006). Okon (1983) reported that a diet low in fibre is undesirable as it could cause constipation and that such diets have been associated with diseases of the colon like piles, appendicitis and cancer. This is an indication that cashew kernel flour can be incorporated in the formulation of snack products. Ebere et al., (2015) reported an increase in fibre content of cookies formulated from the blends of wheat/cashew apple residue up to 9.4% with 20% incorporation. The consumption of a moderate amount of cashew kernel will suffice in providing a reasonable proportion of the daily dietary need of individuals. Ash content of the defatted sample (1.8%) was significantly lower ($p<0.05$) compared to the undefatted flour (4.7%). The value for ash content of undefatted cashew kernel flour falls within the range of those reported by Aremu et al., (2006) and Omusuli et al., (2009) for cashew nut flour (4.4%) and roasted/defatted cashew nut flour (4.41%), respectively. Pomeranz and

Clifton (1981) have recommended that ash contents of nuts, seed and tubers should fall within the range of 1.5 – 2.2% in order to be suitable for animal feeds. Therefore, defatted cashew kernel flour with ash content of 1.8% can be used for this purpose. The carbohydrate value of the defatted flour (32.2%) is comparatively higher to that of undefatted flour (21.5%). This is an indication that both defatted and undefatted cashew kernel flours are good sources of energy and capable of supplying the daily energy requirement of the body.

Table 1. Proximate compositions of defatted and undefatted cashew kernel flour.

Parameters (%)	Defatted flour	Undefatted flour
Moisture	4.4 ± 0.15^{b}	5.7 ± 0.24^{a}
Protein	34.0 ± 0.01^{a}	19.8 ± 0.02^{b}
Ether extract	1.6 ± 0.02^{b}	47.1 ± 0.01^{a}
Crude fibre	6.2 ± 0.10^{a}	1.2 ± 0.14^{b}
Total ash	1.8 ± 0.02^{b}	4.7 ± 0.10^{a}
Carbohydrate	32.2 ± 0.10^{a}	21.5 ± 0.03^{b}

Results represent mean ± standard deviation of five determinations.
Values not followed by the same superscript within the rows are significantly different ($p<0.05$).

Mineral compositions

The result showed that magnesium content of the defatted cashew kernel flour was the highest (220mg/100g) followed by calcium (75.3mg/100g).The potassium content was 52.0mg/100g and phosphorous value was 24.7mg/100g. These values are significantly higher ($p>0.05$) than those obtained for undefatted cashew kernel flour as presented in Table 2. This result is in a reverse case as the one reported by Omosuli et al., (2009). They reported that the most abundant of the mineral composition of roasted and defatted cashew nut flour was potassium followed by magnesium then calcium and was in a close agreement with the observation of Aremu et al., (2006). Magnesium content observed in this study as the richest mineral compared favourably with the values reported by Offem (1990) for melon seed, soybean and cocoa bean. Iron and sodium are the least abundant minerals in this study with the values of 11.8mg/100g and 7.8mg/100g, respectively. It was observed that all the analysed mineral components were significantly higher ($p<0.05$) in defatted cashew kernel flour than the undefatted sample except manganese with significantly lower value in the defatted flour (2.9mg/100g). This observation is in agreement with the report of Hussain et al., (2008) who reported that partial defatting resulted in a significant increase in the mineral content of the flaxseed flours. This is an indication that fat content in cashew kernel and flaxseed flours is an anti-mineral element. Generally, defatted and undefatted cashew kernel flour is comparatively low in phosphorous, iron, sodium and manganese when compared to the values of melon seed and soybean but the values are high enough to contribute significantly to the Nigerian diet and thus mitigate the prevalent micronutrient deficiency disease.

Table 2. Mineral content of defatted and undefatted cashew kernel flour

Parameters (mg/100g)	Defatted flour	Undefatted flour
Phosphorous	24.7 ± 0.20^{a}	8.3 ± 0.03^{b}
Iron	11.8 ± 0.15^{a}	9.0 ± 0.12^{b}
Calcium	75.3 ± 0.10^{a}	59.0 ± 0.20^{b}
Sodium	7.8 ± 0.03^{a}	5.0 ± 0.01^{b}
Potassium	52.0 ± 0.15^{a}	6.8 ± 0.04^{b}

ISSN 2056-5798(Print), ISSN 2056-5801(online)

Magnesium	220±0.24[a]	190±0.12[b]
Manganese	2.9±0.07[b]	9.0±0.14[a]

Results represent mean± standard deviation of five determinations.
Values not followed by the same superscript within the rows are significantly different ($p<0.05$).

Functional properties

The essentials in determining the potential uses for cashew kernel flour are its functional properties. The bulk density of the cashew kernel flour was highest in the undefatted flour (0.2g/ml) and lowest in defatted flour (0.1g/ml) as shown in Table 3. From the result, it is obvious that defatting cashew kernel flour reduces its bulk density. This observation is in agreement with the result of Hussain et al., (2008); they reported that bulk density of the flours decreases as a result of defatting process. Bulk density plays an important role in packaging, transportation of food products and decreases porosity of materials due to surface properties (Milson & Kirk, 1980). Water absorption capacities for defatted flour (7.7%) was significantly higher than the undefatted flour (0.8%) and were very low when compared to the values of water absorption capacities of soybean (130%) and cowpea (100%) as reported by Lin et al., (1974). However, the defatted flour absorbed more water and fat than the undefatted flour. The fat absorption capacity for the defatted flour was significantly different ($p<0.05$) than the undefatted sample with the values of 20.0% and 6.2%, respectively. The values reported in this work are lower than those reported for most nuts and seeds; pumpkin seed 87%, wheat flour 84.2% and soy flour 84.4% (Olaofe et al., 1994). It was high than the values of roasted full fat and roasted defatted (1.31 and 1.27g/g, respectively) for flaxseed flours as reported by Hussain et al., (2008) and gourd seed 6%. Defatted cashew kernel flour can be useful in production of low-fat bakery products and used as flavour carriers or modifiers in fabricated foods as meat analogues. Good flavour carriers should bind flavours tightly, retain it during processing and release it during mastication of the food in the mouth.

The result showed that foam capacity (4.0ml) and stability (106ml) at 30 min was higher in defatted cashew kernel flour than the undefatted flour. This is similar to the report of Hussain et al., (2008) who reported decreased in roasted as compared to non-roasted flaxseed flours. Giami and Bekebian (1992) also reported that the foam of the defatted flour was more stable than that of the full fat samples. At 1h, the volume of foam stability both for defatted and undefatted (106 and 104 ml, respectively) remains constant as at 30 min. This is an indication that foam stability attained its maximum volume at 30 min. There was no significant difference ($p>0.05$) between the emulsion capacities of defatted and undefatted cashew kernel flour with the mean values of (5.0%). Emulsion stability at 30 min and 1h had the same value and defatted flour is reported to have high stability value than undefatted flour (88.0 and 84.0%), respectively. These values are higher than those reported for wheat and soybean flours (7.1 and 18.0%), respectively. This shows that cashew kernel flour can be substituted for soybean/wheat flours as meat extenders/binders in stabilizing colloidal fat and in turn reduce the importation of wheat flour into Nigerian country. The nitrogen solubility of cashew kernel flour was highest for defatted flour at pH 8.0 (0.6%) compared to undefatted flour (0.2%). At pH 9.0, both defatted and undefatted samples had constant nitrogen solubility value of 0.8%.

Table 3.Functional properties of defatted and undefatted cashew kernel flour

Parameters	Defatted flour	Undefatted flour
Bulk density (g/ml)	0.1±0.00 [a]	0.2±0.01[a]
Water absorption capacity (%)	7.7±0.20[a]	0.8±0.01[b]
Fat absorption capacity (%)	20.0±0.50[a]	6.2±0.03[b]

ISSN 2056-5798(Print), ISSN 2056-5801(online)

Foam capacity (ml)	4.0±0.02^{a}	3.9±0.01^{a}
Foam stability (30 min)	106±0.70^{a}	104±0.60^{a}
Foam stability (1h)	106±0.50^{a}	104±0.50^{a}
Emulsion capacity (%)	5.0±0.04^{a}	5.0±0.04^{a}
Emulsion stability (30 min)	88.0±0.03^{a}	84.0±0.02^{b}
Emulsion stability (1h)	88.0±0.02^{a}	84.0±0.01^{b}
Nitrogen solubility ($pH_{8.0}$)	0.6±0.01^{a}	0.2±0.01^{b}
Nitrogen solubility ($pH_{9.0}$)	0.8±0.05^{a}	0.8±0.01^{a}

Results represent mean ± standard deviation of five determinations.
Values not followed by the same superscript within the rows are significantly different ($p<0.05$).

CONCLUSION

The important parameters in determining the potential uses for cashew kernel flour are its proximate, mineral and functional properties. From the results, it can be concluded that defatted cashew kernel flour is a good source of crude fibre and protein as it can provide the recommended daily intake of protein for children. This indicates that the flour can serve as a functional ingredient in the formulation of snack products, be substituted for soybean since the fibre content compares very well with those of legumes/wheat flours and in turn reduce the importation of wheat flour into Nigeria. Defatted cashew kernel flour with ash content of 1.8% falls within the recommended range for animal feed and can also be used for this purpose. Generally, it was observed that all the nutrient content, minerals and functional properties were significantly high ($p<0.05$) in defatted cashew kernel flour than the undefatted sample. Therefore, cashew kernel flour can be defatted and used as a potential source of raw material for food and feed industries.

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ISSN 2056-5798(Print), ISSN 2056-5801(online)